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14. ABSTRACT
The objective of the project titled “Acquisition of Stereoscopic Particle Image Velocimetry (S-PIV) System for Investigation of Unsteady Flows” is to procure a state-of-the-art S-PIV system and essential accessories, to enhance the quality and scope of experimental aerodynamics/fluid dynamics research at California State University Northridge (CSUN). For this project, the PI requested quotes from three vendors for the S-PIV system, with specific requirements regarding laser, camera, and system capabilities. After assessing the capabilities of each of the systems available from all three vendors, recommendations for acquisition of S-PIV system were submitted to

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Particle Image Velocimetry

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a. REPORT	b. ABSTRACT	c. THIS PAGE			Vibhav Durgesh
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Report Title

Final Report: Acquisition of Stereoscopic Particle Image Velocimetry System For Investigation of Unsteady Flows

ABSTRACT

The objective of the project titled "Acquisition of Stereoscopic Particle Image Velocimetry (S-PIV) System for Investigation of Unsteady Flows" is to procure a state-of-the-art S-PIV system and essential accessories, to enhance the quality and scope of experimental aerodynamics/fluid dynamics research at California State University Northridge (CSUN). For this project, the PI requested quotes from three vendors for the S-PIV system, with specific requirements regarding laser, camera, and system capabilities. After assessing the capabilities of each of the systems available from all three vendors, recommendations for acquisition of S-PIV system were submitted to the University's purchasing department. The S-PIV system was delivered at the end of September 2015, and the PI and the students working in the experimental fluids lab attended a two-day workshop focused on assembling and operating the S-PIV system. This system will enable the PI and senior personnel to pursue diverse fluid dynamics research, which would not have been otherwise possible at CSUN. Finally, the research projects facilitated by the S-PIV system will help provide unique research opportunities to under-represented and minority students at CSUN, and thereby support their effective integration into research enterprise.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

Number of Presentations: 0.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received Paper

TOTAL:

Number of Manuscripts:

Books

Received Book

TOTAL:

Received	Book Chapter

TOTAL:

Patents Submitted

Patents Awarded

Awards

Graduate Students

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Post Doctorates

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Names of Faculty Supported

NAME	PERCENT_SUPPORTED	National Academy Member
Vibhav Durgesh	0.00	
Hamid Johari	0.00	
FTE Equivalent:	**0.00**	
Total Number:	**2**	

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: 0.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:..... 0.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):..... 0.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields: 0.00

Names of Personnel receiving masters degrees

NAME

Total Number:

Names of personnel receiving PHDs

NAME

Total Number:

Names of other research staff

NAME	PERCENT_SUPPORTED

FTE Equivalent:

Total Number:

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

Technology Transfer

Final Progress Report - Grant # W911NF1510061
DoD Research and Education Program for HBCU/MI Equipment/Instrumentation
Acquisition of Stereoscopic Particle Image Velocimetry System for Investigation of Unsteady Flows

PI Name: Vibhav Durgesh
Senior Personnel: Hamid Johari

Statement of problem studied

The objective of the project titled "Acquisition of Stereoscopic Particle Image Velocimetry (S-PIV) System for Investigation of Unsteady Flows" was to procure a state-of-the-art S-PIV system and essential accessories, to enhance the quality and scope of experimental aerodynamics/fluid dynamics research at California State University Northridge (CSUN). The S-PIV system was acquired through the Department of Defense (DoD) Research and Education Program for Historically Black Colleges and Universities and Minority-Serving Institutions (HBCU/MI). The purpose of funding under this Broad Agency Announcement (BAA) is to support the acquisition of research equipment and instrumentation by HBCU/MI to augment existing capabilities or to develop new capabilities in technical areas of interest to the DoD. This includes basic equipment for use in research and education programs, as well as more sophisticated equipment and instrumentation for faculty research.

Summary of key results

The PI obtained quotes from threee separate vendors for the S-PIV system. One of the three vendors was selected by the PI and senior personnel after analyzing the capabilities of the S-PIV sytem available with each vendor. Once the vendor was finalized, an order was placed for the S-PIV system and it was delivered at the end of September 2015.

Figure 1: Student researchers were trained to operate and maintain the S-PIV system by the engineer from the S-PIV vendor, during a two-day workshop.

Table 1: List of major items procured for this project

S-PIV Components
Nd:YAG Dual Cavity pulsed laser - Quantel Evergreen PIV 200, 2 x 200 mJ/pulse at 532 nm
Articulating arm for guiding laser beams
Dual frame CCD 8MP camera (2 cameras for S-PIV measurement) - Imager LX 8M Camera
Sheet optics and required lenses optics, mounts and filters
Scheimpflug Camera Lens Adapter (Series 3)
Camera Lens Filter - Narrow band pass, 532 nm
Stereo PIV Calibration Target
Camera rail mount
Programmable Timing Unit (PTU-X); Internal
Seeding materials along with atomizer
Essential S-PIV software along with high performance computer
Post-processing software for S-PIV
Protective eye wear to safely work with high power pulsed laser

Table 1 shows the major components of the S-PIV system procured through this project, along with supplies essential for the day-to-day operation of the S-PIV system. The post-processing software procured with the S-PIV system allowed for analysis of the S-PIV data in greater detail, which would not have been otherwise possible. After the delivery and initial testing of the S-PIV system, the PI arranged for a workshop to train student researchers to operate the S-PIV system. An engineer from the S-PIV vendor conducted the two-day training workshop at CSUN, which was attended by students and faculty members (see Figure 1). Both undergraduate and graduate students from diverse cultural backgrounds attended the S-PIV workshop. Moreover, the critical training sessions and instructions provided by the S-PIV engineer were recorded for future reference. The workshop allowed students to gain a detailed understanding about the S-PIV hardware and software. Towards the conclusion of the workshop, students were able to successfully operate the S-PIV system.

After the training workshop, the S-PIV system was installed in the CSUN experimental fluid dynamics laboratory, as shown in Figure 2. The system has been setup for performing S-PIV measurements in the CSUN water tunnel facility, which has a test section of 8ft by 2ft by 2ft, and optical access for performing S-PIV measurements. This research facility will be used for conducting several aerodynamics research projects. Currently, one undergraduate student researcher is using the S-PIV system to perform flow field measurements over airfoils at low Reynolds number values. These measurements will provide an insight into the complex fluid flow phenomena at low Reynolds number values. A sample S-PIV result from this research, showing the normalized stream-wise velocity contour overlaid with the velocity vector and streamlines close to the suction side of the airfoil surface, is provided in Figure 3. Flow field measurements of this nature would not have been possible without the availability of the S-PIV

system; the S-PIV system has thus significantly enhanced fluid dynamics measurement capabilities at CSUN. In the coming semester, one graduate student researcher will use the S-PIV system to characterize the aerodynamic performance of airfoils when operating in the wake of a bluff body (a project focused with DoD application), while another graduate student will begin a new research project that focuses on understanding the fluid dynamics of flow inside an aneurysm.

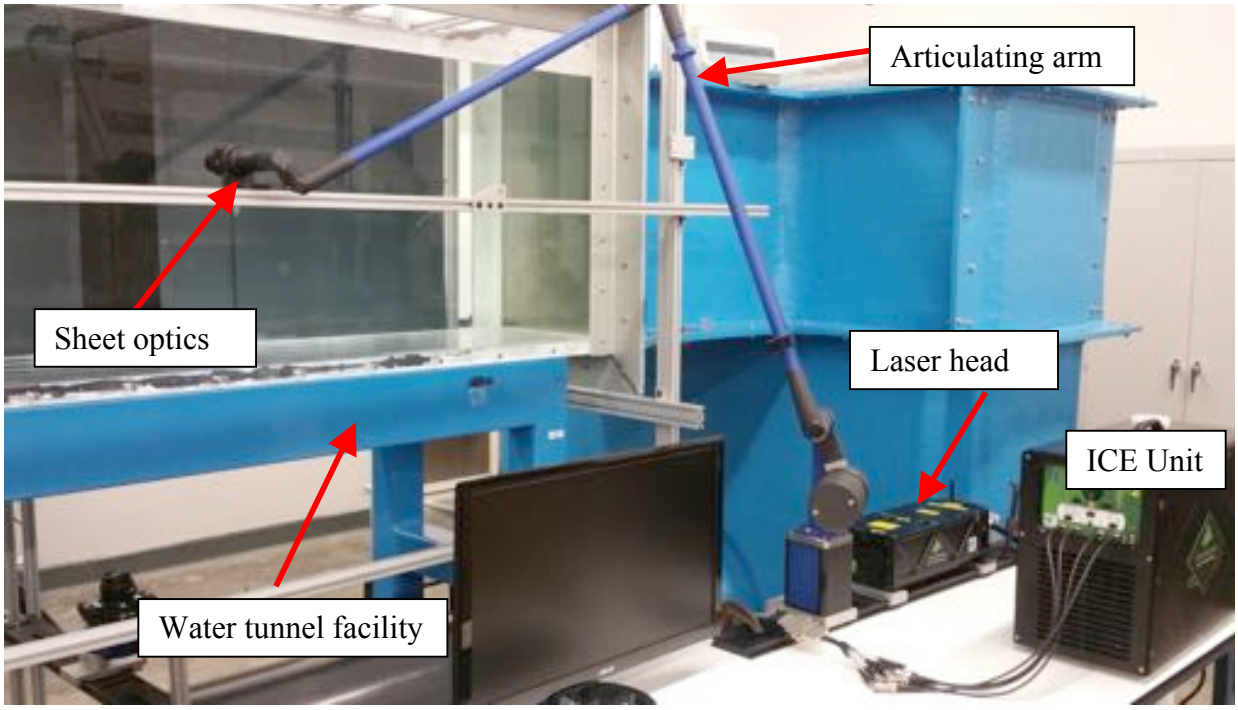

Figure 2: S-PIV system installed in the water tunnel facility for conducting flow field measurements.

In summary, the availability of the S-PIV system at CSUN has enabled the PI and co-PI to conduct diverse and complex fluid dynamics research, and compose viable proposals to obtain further funding. This in turn has provided opportunities for underrepresented and minority students at CSUN to work on challenging research projects. The PI anticipates that the availability of the S-PIV system will have a far-reaching positive impact on students as their involvement in advanced research will motivate them to purse careers in the fields of aerodynamics/ fluid dynamics research and technology. The acquisition of the S-PIV system has already initiated the collaborative process among faculty members and helped expose students to cutting edge research.

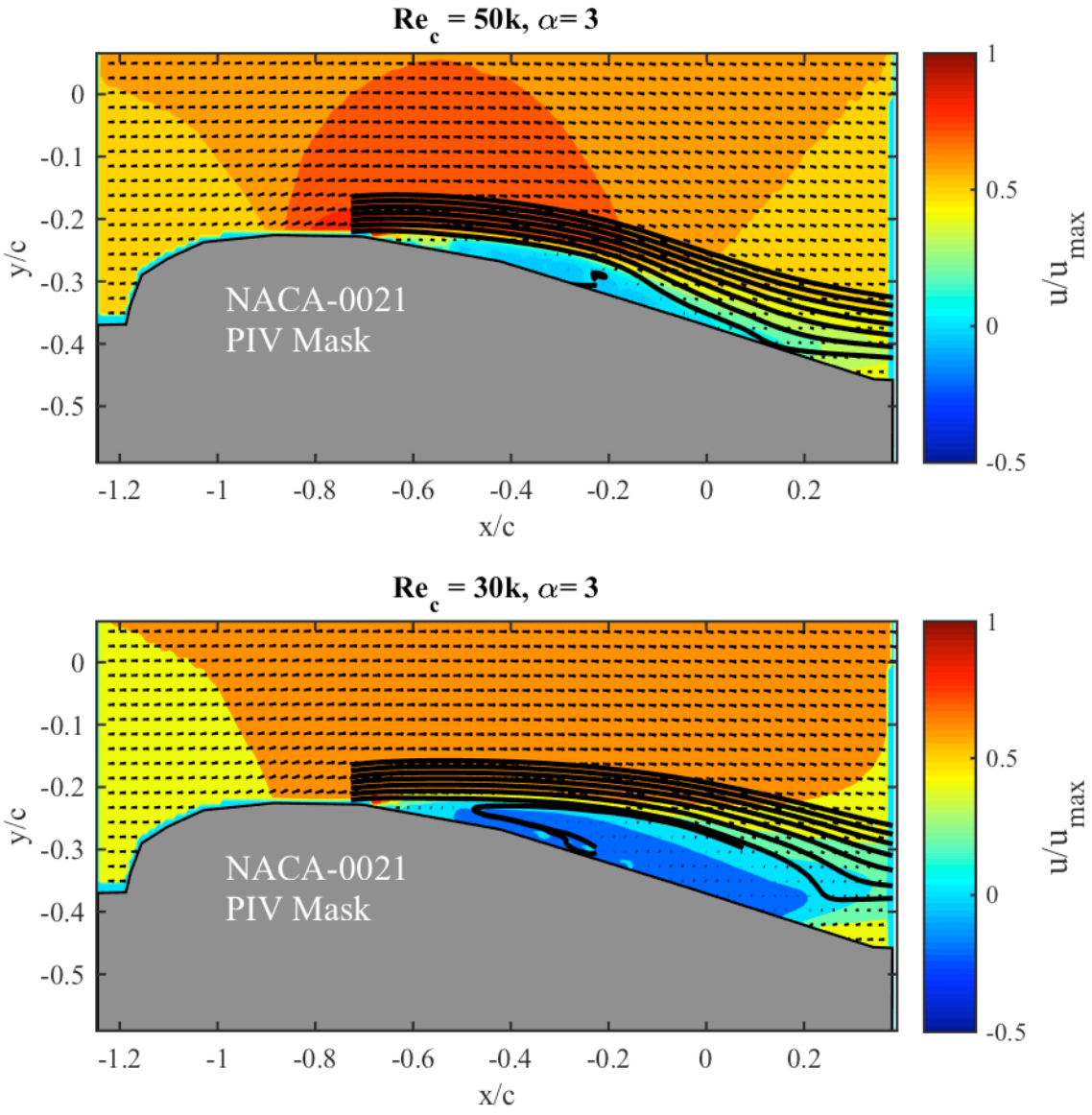

Figure 3: Flow field measurement on the suction side of NACA-0021 airfoil using S-PIV system.